233 Ultramarathon Running Injuries

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Abstract

Ultramarathon races (i.e., any distance in excess of the standard marathon distance of 42,195 km) have gained popularity in recent years, often taking place in extreme and savage environmental conditions and testing the limits of human endurance. The human body often demonstrates a remarkable adaptation to these challenges, but still overuse musculoskeletal injuries and illnesses are common.

Introduction

The human body is well suited to running long distances, evolving for persistence hunting – capable of covering great distances in pursuit of prey. But ultramarathons test the limits of human endurance. Tales of epic feats of human endurance are myriad since the death of the first marathon runner, Pheidippides. In addition to the endurance load, ultramarathons often take place in extreme and savage environmental conditions – with regular races staged in Antarctica, the Sahara Desert, and the Amazon Jungle, among others (Fig. 1).

Numerous studies have looked at musculoskeletal injuries and illnesses in runners, but relatively few have assessed the impact of ultramarathon on the human body. Few have often demonstrate both remarkable adaptation to this challenge and significant musculoskeletal injury and illness. Injuries are usually overuse in nature, while the ultramarathoner frequently presents a challenge

Fig. 1 Ultra-runners on Mt Kilimanjaro

to the clinician, often being extremely reluctant to pull out of a race or decrease training despite relevant symptoms and clinical signs.

This chapter gives an overview of the most common injuries, medical problems, and challenges that physicians face when looking after these athletes.

Musculoskeletal Injuries

Patellofemoral Syndrome (PFPS): Runner's Knee

Patellofemoral pain syndrome has been described as the most common musculoskeletal injury in ultramarathon runners, accounting for up to 31.3 % of musculoskeletal injuries (Fallon 1996; Bishop and Fallon 1999; Taunton et al. 2002; Scheer and Murray 2011).

PFPS is a term used for a variety of pathologies, including bony abnormalities of the patella, malalignment of the lower extremity, muscular dysfunction, or overuse stress to the patellofemoral joint (Thomeé et al. 1999; Collado and Fredericson 2010).

Predisposing factors include muscular imbalance between the medial and lateral stabilizing structures of the patella. Tightness in the hamstrings and gastrocnemius muscle has been postulated to lead to an increased Q angle. Patella anatomical variants, leg length discrepancies, genu valgum or recurvatum, and hyper-pronation at the subtalar joint can all be contributing factors (Collado and Fredericson 2010; Lankhorst et al. 2012). It presents with an ill-defined ache over the anterior knee which typically worsens with continued running, especially hill running. It is frequently bilateral. Examination findings are often subtle and predisposing factors can give clues to the diagnosis.

Treatment includes rest, ice, and analgesia. It also includes quadriceps strengthening exercises, hip strengthening exercises, patellar taping or bracing, soft tissue mobilization, stretching, and activity modification. Surgery is rarely indicated (Collado and Fredericson 2010)

Iliotibial Band Syndrome (ITBS)

Iliotibial band syndrome (ITBS) is the most common cause of lateral knee pain in runners, accounting for up to 12 % of all running-related overuse injuries (Taunton et al. 2002; Fredericson and Weir 2006; Strauss et al. 2011).

The iliotibial band (ITB) is part of the lateral thickening of the tensor fascia lata, which envelops the thigh. Repetitive knee flexion causes friction and impingement when sliding over the lateral femoral epicondyle causing irritation, inflammation, and pain (Fredericson and Weir 2006). The ITB may also compress highly vascularized and innervated layers of fat, connective tissue, or other structures causing discomfort (Fairclough et al. 2007).

Factors predisposing to ITBS are increased training load, downhill running, overstriding, and knee flexion and extension (Fredericson and Weir 2006; Fairclough et al. 2007; Strauss et al. 2011).

Diagnosis is mainly clinical. Symptoms are that of lateral knee pain during running at a reproducible time or distance especially on downhill running. Local tenderness and sometime swelling or crepitus over the distal ITB may be present. Imaging is usually not required but may be appropriate to rule out other pathologies. Treatment includes activity modification, rest, ice, analgesia, and corticosteroid injection in cases of severe pain or swelling. In rare refractory cases that do not respond to conservative treatment, surgery may be considered (Fredericson and Weir 2006; Fairclough et al. 2007; Strauss et al. 2011).

Medial Tibial Stress Syndrome (MTSS)

MTSS accounts for up to 10 % of lower leg injuries among ultramarathon runners (Hutson 1984; Fallon 1996). Different terms used to describe MTSS include: shin soreness, shin splints, tibial stress syndrome, medial tibial periostitis, and medial tibial traction periostitis (Moen et al. 2009; Reshef and Guelich 2012). Possible mechanisms include overuse due to repeated tibial bending and bowing causing bone strain and repeated traction on the periosteum of the tibia. Predisposing factors are previous history of MTSS, female sex, hyper-pronation, decreased muscular endurance, training errors, hard running surfaces, unsuitable shoe design, and inexperienced runners (Moen et al. 2009; Craig 2009; Reshef and Guelich 2012).

MTSS presents with leg pain on the posteromedial border of the tibia that occurs during exercise. Pain can be elicited by palpation over the distal two thirds of the posteromedial border of the tibia. Mild edema may also be present, but not frequently (Moen et al. 2009; Reshef and Guelich 2012).

Diagnosis is clinical but sometimes MRI may be indicated to exclude stress fractures. Treatment includes activity modification, ice, analgesia, physiotherapy, stretching, and most importantly modification of risk factors. Surgical treatment is rarely indicated, but includes fasciotomy along the posteromedial border of the tibia (deep posterior compartment) (Moen et al. 2009; Craig 2009; Reshef and Guelich 2012).

Chronic Exertional Compartment Syndrome (CECS)

CECS accounts for up to 11 % of muscular skeletal injuries in ultramarathon runners (Fallon 1996; Bishop and Fallon 1999). It is an overuse injury. Increased pressure within the compartment can lead to ischemia, decreased tissue perfusion, and pain (Fraipont and Adamson 2003; George and Hutchinson 2012).

Pain is usually experienced at a reproducible, well-defined distance during the run. The character is often described as "cramp-like" or "burning" over the involved compartment that worsens with continued running until exercise must be stopped. The condition is frequently bilateral (George and Hutchinson 2012).

At rest, physical examination is unremarkable, but immediately after exercise the affected compartment may be tender and muscle herniation may sometimes be felt. This is, however, not a constant sign. In more severe cases muscular weakness, paresthesia, or muscle wasting may be present (George and Hutchinson 2012).

Diagnosis is usually clinical but medial tibial stress syndrome and tibial or fibula stress fracture should be excluded as they may coexist in up to 30 % of patients. Compartment pressure measurements are the gold standard for diagnosing CECS. Treatment is conservative with activity modification, relative rest, analgesia, physiotherapy, and manual therapy. If conservative treatment fails, fasciotomy of the involved compartments, i.e., the anterior and lateral compartments, is indicated (Fraipont and Adamson 2003; George and Hutchinson 2012).

Achilles Tendinopathy

Achilles tendinopathy is a prevalent overuse injury affecting up to 19 % of ultramarathon runners (Hutson 1984; Fallon 1996; Bishop and Fallon 1999; Scheer and Murray 2011; Lopes et al. 2012).

It presents with gradual onset of activity-related pain that can often be "run through" but worsens with prolonged and continued training. There is focal tenderness to palpation and decreased muscle strength in the affected leg. Morning stiffness that improves with activity may be present and a mild swelling over the Achilles tendon and crepitus may in some cases be palpated (Clement et al. 1984; Maffulli and Kader 2002; Skjong et al. 2012). Diagnosis is usually clinical.

Predisposing factors include previous injury or tendon abnormalities, training errors, rapidly increasing training load, hard and/or uneven running surfaces, inappropriate footwear, male sex, increased age, obesity, and abnormal lower limb biomechanics (Clement et al. 1984; Maffulli and Kader 2002; Taunton et al. 2002).

Treatment strategies include relative rest, activity modification, and ice and analgesia in the acute stage. Eccentric exercises have shown good short-term benefits for midportion tendinopathy, while insertional tendinopathy responds less well to this protocol, and surgery is more often needed in case of insertional tendinopathy (Clement et al. 1984; Skjong et al. 2012).

"Ultramarathoner's Ankle:" Anterior Ankle Tendinitis

The "ultramarathoner's ankle" is an injury relatively specific to ultramarathon running and has been reported in 1.4 % of ultramarathon runners (Hutson 1984; Fallon 1996; Bishop and Fallon 1999; Scheer and Murray 2011).

Repetitive plantar flexion and dorsiflexion cause a peritendinitis/tendinitis of the tendons passing under or adjacent to the extensor retinaculum of the ankle. Other causative factors include excessive pressure on the dorsum of the ankle due to tight-fitting shoes, over-pronation, running on hard surfaces, and overstriding (Hutson 1984; Fallon 1996).

Ultramarathoner's ankle presents with anterior ankle pain, initially vague, becoming sharper and more localized with continued running. Swelling over the anterior ankle can be observed and sometimes crepitus is noted. There is pain on resisted dorsiflexion. Treatment is nonsurgical and includes modification of risk factors, relative rest, ice, analgesia, and taping. Physiotherapy, cast immobilization, eccentric strengthening exercises, steroid injection, and stretching may also be beneficial (Fallon 1996; Vaseenon and Amendola 2012).

Diagnosis is clinical but sometimes ultrasonography and/or MRI may be helpful to exclude tendon ruptures, impingement, or stress fractures (Vaseenon and Amendola 2012).

Stress Fractures

Stress fractures are common among runners and are usually fatigue fractures that develop through overuse in healthy bone (Harrast and Colonno 2010; Pegrum et al. 2012). Common sites for stress fracture are the tibia, fibula, and navicular and metatarsal bones. Less frequent, but recognized stress fractures include those of the inferior pubic ramus, sacrum, medial malleolus, femoral shaft, and femoral neck (Harrast and Colonno 2010; Pegrum et al. 2012). Predisposing factors include previous history of stress fractures; an increase in frequency, duration, and intensity of training loads; inadequate recovery, hard or cambered training surfaces; inappropriate or old training shoes; excessive hip adduction; leg length discrepancies; malalignment of the lower extremities and foot mechanics; and female sex. Symptoms include localized pain over the fracture site, which is of insidious onset. On examination focal bony tenderness can be palpated and sometimes (infrequently) edema may be present. MRI is considered the gold standard for the evaluation of stress fractures (Harrast and Colonno 2010; Pegrum et al. 2012; McCormick et al. 2012).

Treatment depends on the location of the stress fracture, but always includes relative or total rest. Once healed, modifying identified predisposing factors can minimize the likelihood of recurrence.

Other Health-Related Problems

Blisters

Friction blisters are the most common medical problem – affecting 26–76 % of ultramarathon runners. They can cause pain and lead to infection, and withdrawal from competition (Murray et al. 2010; Scheer and Murray 2011; Hoffman and Fogard 2011; Krabak et al. 2011).

Blisters usually form due to excessive frictional forces under the foot, which results in epidermal splits and separated skin layers. Hydrostatic pressure allows the separated areas to fill with fluid or blood forming a blister. Risk factors for blister formation include poorly fitting shoes, excessive training loads, carrying heavy loads, vigorous activities, and individual factors such as skin surface roughness and hydration status. Preventative strategies require further evaluation but always include application of antiperspirants, lubricants, and solutions to harden skin (Knapik et al. 1995; Mailler and Adams 2004; Mailler-Savage and Adams 2006). Choice of sock is a popular debate topic among runners!

Painful blisters are usually lanced and drained under sterile conditions. Other blister treatments include injecting iodine into the blister, which seals the blister. This procedure can be very painful.

Chafing

Chafing is a superficial skin inflammation due to increased friction when skin surfaces rub together. In ultramarathon runners chafing has been reported in 8.7–41.9 % of runners, mostly in the groin, back, and nipple area (Murray et al. 2010; Scheer and Murray 2011).

Treatment consists of a topical corticosteroid cream to reduce inflammation. Preventative strategies include: drying the area manually, applying drying or talcum powder, and reducing the friction with petroleum jelly, adhesive tape, and well-fitting clothes (Mailler and Adams 2004).

Exercise-Associated Collapse (EAC)

Exercise-associated collapse is the most frequent cause of collapse at the finish line of races and manifests as an inability to stand or walk unaided as the result of light-headedness, faintness, dizziness, or syncope usually on the completion of exercise. A postural drop in systolic blood pressure has been reported in 0.9 % of ultramarathon runners (Holtzhausen et al. 1994; Holtzhausen and Noakes 1995; Speedy et al. 2003; Scheer and Murray 2011). EAC is a collapse in the absence of neurological, biochemical, or thermal abnormalities and is a diagnosis of exclusion (Speedy et al. 2003; Asplund et al. 2011).

Exercise-associated collapse is multifactorial, but the main mechanism leading to collapse is a transient postural hypotension caused by an impaired baroreflex response, with decreased vascular resistance and a loss of the lower leg muscle pump action. This results in lower extremity vasodilatation and blood pooling once the athlete crosses the finish line or stops running. There is no conclusive evidence, however, that dehydration and hyperthermia are the main mechanism.

Treatment includes placing the runner in the supine position with legs elevated (Trendelenburg's position) and offering moderate oral rehydration (see Fig. 2). Additionally, local skin surface cooling may help direct peripheral blood flow centrally and decrease cardiovascular strain. Runners generally recover quickly (Holtzhausen et al. 1994; Holtzhausen and Noakes 1995; Asplund et al. 2011; Anley et al. 2011).

Exercise-Associated Hyponatremia (EAH)

Exercise-associated hyponatremia is a dilutional hyponatremia due to excessive fluid consumption

Fig. 2 Collapsed runner receiving treatment during the Al Andalus Ultimate Trail 2012

of water or sports drinks and can be a life-threatening condition. Serum or plasma sodium concentrations ([Na^+]) are below 135 mmol/L (Noakes et al. 1985, 2004; Hew-Butler et al. 2008; Knechtle et al. 2011).

Early signs are nonspecific and may include weight gain, bloatedness, nausea, vomiting, and headache. Progressive symptoms include confusion, seizures, respiratory distress, cerebral and pulmonary edema, and death (Noakes et al. 1985, 2004; Hew-Butler et al. 2008).

Treatment is based on sodium levels and symptoms. In asymptomatic individuals with [Na^+] <135 mmol/l, oral fluid intake should be restricted and urine output monitored. In symptomatic runners immediate on-site administration of hypertonic saline is indicated. Intravenous administration of normal saline or hypotonic fluids is contraindicated as it can exacerbate hyponatremia. If on-site [Na^+] testing is not available, suspected cases should be transferred to the hospital without delay (Hew-Butler et al. 2008).

Risk factors include excessive drinking, slow running pace, prolonged running, event inexperience, female sex, low body weight, weight gain during competition, and certain drugs such as NSAIDs. Drinking ad libitum (according to thirst) decreases the incidence of this life-threatening condition (Noakes et al. 1985, 2004; Hew-Butler et al. 2008).

Many illnesses at endurance events are attributed to dehydration. This effect has been exaggerated over the years, perhaps perpetuated by advertisers and the sports drink industry. There are few if any reports of death from dehydration, but many from hyponatremia. Drinking to thirst is a sensible advice to give competitors.

Exertional Heatstroke (EHS)

Exertional heatstroke is characterized by a core body temperature of >40°C, associated with an altered mental state and/or organ failure, induced by exercise (Armstrong et al. 2007; Childress et al. 2010; Asplund et al. 2011). It is considered a medical emergency and should be treated as such.

Early symptoms are nonspecific including headache, nausea, vomiting, diarrhea, and confusion progressing to inability to walk, collapse, seizures, and coma (Smith 2005; Armstrong et al. 2007; Rae et al. 2008).

Treatment consists of immediate cooling through immersion of the athlete in a bathtub with ice water to decrease core body temperature to approximately 38°C. Runners should always be transferred to a medical facility for observation. The majority of runners recover fully especially if they are cooled immediately and if body temperature and cognitive function return to normal within an hour of onset of symptoms (Costrini 1990; Holtzhausen and Noakes 1997; Speedy et al. 2003; Smith 2005; Armstrong et al. 2007; Childress et al. 2010).

Risk factors include incomplete heat acclimatization, hot ambient air temperature, high relative humidity, high exercise intensity and duration, dehydration, concomitant viral illness, fever,

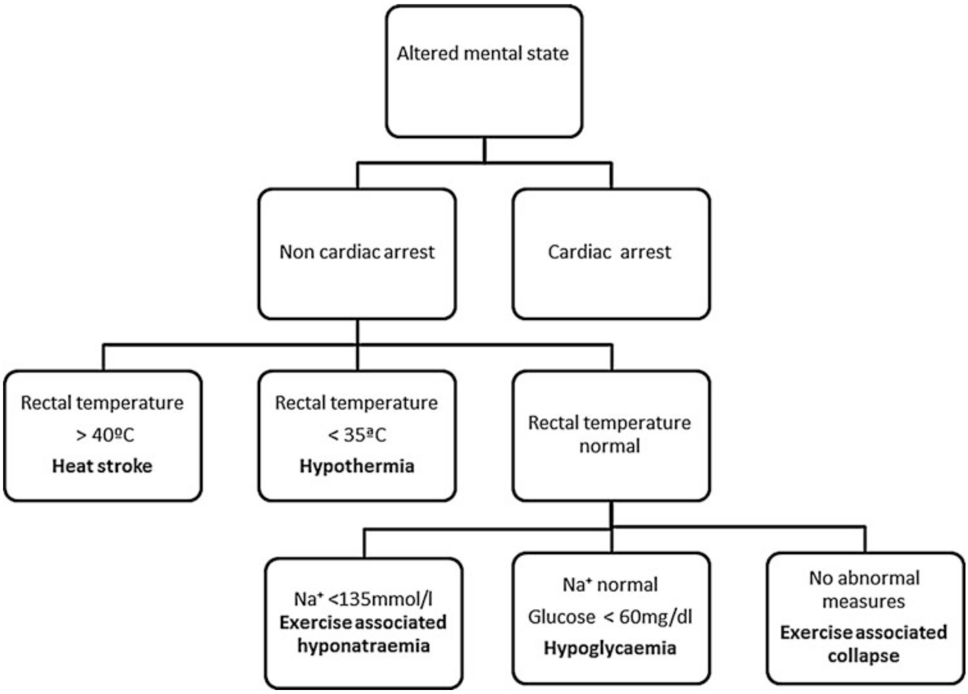

Fig. 3 Flowchart. Approach to the collapsed athlete

diarrhea, vomiting, male sex, obesity, sleep deprivation, alcohol consumption, and predisposition to malignant hyperpyrexia. But even seemingly healthy individuals in cool environments can suffer from exertional heat stroke (Costrini 1990; Smith 2005; Armstrong et al. 2007). Symptoms must correlate with an increased core body temperature. An athlete does not have EHS if they have a normal temperature.

Hypothermia

Symptoms can range from simply feeling cold, shivering, and mild confusion to life-threatening condition including loss of consciousness and cardiovascular collapse.

Risk factors include inactivity, fatigue, lack of sleep, hypoglycemia and hypothyroidism, wet clothing, wind and rain, and impaired thermoregulation such as older age, trauma, drugs, alcohol, and infection (Castellani et al. 2006).

Preventative measures include identifying any potential hazards before exercising in cold weather, wearing additional and appropriate clothing and offering warming facilities at the event, and possibly canceling the event in adverse weather conditions.

Treatment includes removing the runner from the cold, and in mild hypothermia, immediate re-warming may be sufficient. In severe cases transfer to a medical facility is urgently indicated (Speedy et al. 2003; Castellani et al. 2006).

Approach to the Collapsed Runner

Collapse during or after endurance event is a common problem. Life-threatening conditions need to be recognized and treated appropriately (Holtzhausen and Noakes 1997; Speedy et al. 2003; Asplund et al. 2011). The flow chart gives an overview of the various conditions and an approach to the collapsed athlete (Fig. 3).

Runners that collapse on course are more likely to have a sinister cause for their collapse than runners that collapse after crossing the finish line, who are more likely to suffer from exercise-

Fig. 4 Runner encountering the local wildlife

associated collapse (Holtzhausen and Noakes 1997; Speedy et al. 2003; Childress et al. 2010; Asplund et al. 2011). Following a standard ABC (airway, breathing, circulation) check and if necessary initial resuscitation, assessment includes mental state, conscious level, blood pressure, rectal temperature, serum glucose and sodium concentration, and hydration status. A working diagnosis needs to be established before treatment is initiated (Noakes 1995; Holtzhausen and Noakes 1997; Speedy et al. 2003).

Serious pathology can be suspected if the athlete is unconscious with systolic blood pressure <100 mmHg and heart rate >100 beats per minute. If the rectal temperature is >40°C, heat stroke is suspected, and if temperature is <35°C, hypothermia is the diagnosis. If temperature is normal and sodium concentration is <135 mmol/l, exercise-associated hyponatremia is likely. If the blood glucose measurement is below 60 mg/dl, hypoglycemia should be treated. In the event of cardiac arrest, advanced life support algorithms must be followed. Early use of an automated external defibrillator (AED) is critical.

Medical Provision at Ultramarathon Races

Medical teams should be comfortable in treating running and non-running-related injuries. Experience in sports medicine, emergency medicine, and general practice is helpful. Team members may include physicians, nurses, and/or allied health professionals that can contribute to an appropriate skill mix (Scheer and Murray 2011; Mansfield et al. 2011).

Careful pre-race planning and risk assessment is important. Environmental conditions, terrain, access and evacuation procedures, communication protocols, language barriers, staffing levels, medical equipment, and pre-race medical screening for any preexisting medical problems should be considered. Race briefings of runners have also been shown to be effective in reducing overall medical risks (Hew Buttler et al. 2008; Scheer and Murray 2011; Scheer et al. 2012).

Most injuries are minor, but serious injuries and deaths have occurred. Equipments such as on-site [Na^+] testing, automated external defibrillator (AED), ice, glucose measurement, rectal thermometers, intravenous fluids, and emergency drugs for medical emergencies can be life saving. The majority of medical encounters happen toward the end of the race course or at the finish line, and up to 60 % of competitors seek advice from the medical team during multistage events, usually prior to or on the longest day of the race (Hutson 1984; Speedy et al. 2003; Scheer and Murray 2011; Asplund et al. 2011).

Doctors providing medical cover should check with their medical defense union that they have adequate indemnity insurance (Mansfield et al. 2011).

Summary

Ultramarathon races (any distance in excess of the standard marathon distance of 42,195 km) place a severe endurance load upon competitors and often take place in extreme environmental conditions and testing the limits of human endurance and performance (Fig. 4).

Overuse musculoskeletal problems are frequent and become increasingly common with an increase in event distance. These injuries include patellofemoral syndrome, Achilles tendinopathy, iliotibial band syndrome, medial tibial stress syndrome, and stress fractures, as well as tendinopathy of the ankle dorsiflexors or "ultramarathoner's ankle."

Other health-related problems include common disorders such as friction blisters, chafing, and exercise-associated collapse. Potentially life-threatening illnesses include exercise-associated hyponatremia, hypoglycemia, exertional heat-stroke, and hypothermia.

Prompt recognition and treatment is usually possible based on an accurate history and examination, while careful pre-race planning and risk assessment is effective in reducing medical risk.

Cross-References

▶ Achilles Tendinopathies
▶ Anatomy and Biomechanics of the Knee
▶ Collapse in Athletes: Etiology and Management
▶ Compartment Syndromes of Thigh and Lower Leg
▶ Imaging of Stress Fractures and Involved Risk of Ionizing Radiation
▶ Patellofemoral Problems in Adolescent Athletes
▶ Physiotherapy in Patellofemoral Pain Syndrome
▶ Tendinopathies Around the Foot and Ankle

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